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(54) Method for compressing, processing, and storing grayscale bitmaps.

(57) A method for image processing includes the steps of scanning an image (20) within a first grid of pixels (22), determining a grayscale value for each pixel scanned in the first grid of pixels, and, for each pixel scanned, activating a number of pixels of a second grid of pixels (25) corresponding to the grayscale value determined. Data representing the second grid of pixels can be compressed, and stored for use in facsimile transmission or photoreprographic image production.

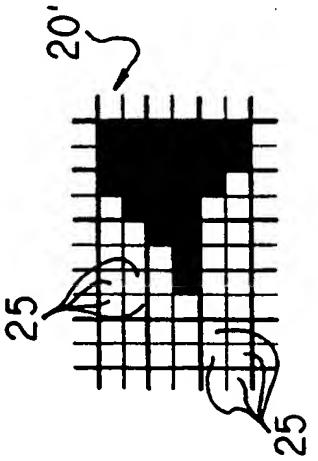

FIG. 4B

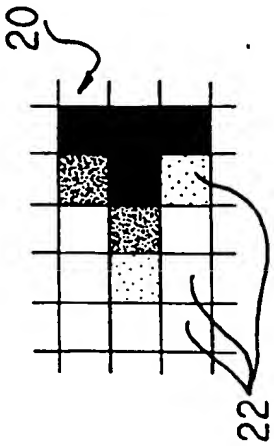

FIG. 4A

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The compressed version of the second most significant bitplane is 2 to 3 times as large as the most significant bit plane because the transition from white to black in the original image, once sampled by the scanner, involves the transition from gray-level 0 (binary 00xxx) to gray-level 1 (binary 01xxx), then 2 (binary 10xxx), then gray-level 3 (binary 11xxx). Thus the most-significant bit is 0, then 0, then 1, then 1, while the 2nd-most significant bit is 0, then 1, then 0, then 1 as the scanner sweeps across the white to black edge. The G4 technique uses 1 Huffman code per transition from pixel-on to pixel-off or vice versa, and the 2nd-most-significant bit map has 3 times as many transitions as the edge is swept across.

Other grayscale compression approaches exist. For example, one approach is the so-called "Gray codes" (see, for example, Logic Design with Integrated Circuits, William E. Wickes, (John Wiley & Sons, New York, 1968) p 14). Another approach is described in the JPEG/MPEG standards. Gray codes have the advantage of being lossless, but would not enable standard G4 compressor/decompresor algorithms-/chips to be used without special adaptations; JPEG/MPEG are, in general, lossy and often introduce unwanted artifacts in images of fine text.

Techniques for up-conversion of low-resolution gray to high-resolution binary are also known, and used in products of the Xerox Corporation, like the Docutech or the 7650 scanner, in which the scanner actually scans at 400 spi gray and interpolates to 600 spi binary.

Reference is also made to K.Y. Wong and B. Schatz, in Graphical and Binary Image Processing and Applications, J. C. Stoffel, ed., (Artech House, Dedham MA, 1982); and US-A-4,124,870.

In light of the above, it is an object of the invention to provide an efficient, rapid, lossless method for compressing, processing, and storing grayscale bitmaps using algorithms that are designed for binary images.

In accordance with a broad aspect of the invention, a method for image processing is presented that includes the steps of scanning an image within a first grid of pixels, determining a grayscale value for each pixel scanned in the first grid of pixels, and, for each pixel scanned, activating a number of pixels of a second grid of pixels corresponding to the grayscale value determined.

Data representing the second grid of pixels can be compressed, and stored for use in facsimile transmission or reprographic image production.

In accordance with another broad aspect of the invention, a method is presented for image processing. The method includes scanning an image to produce a digital representation of the image at a first resolution and with a predetermined number of grayscale values. The digital representation of the image is converted to a digital representation of an image having an increased resolution at least as great as the first resolution times the base-2 logarithm of a predetermined number of grayscale values, and having only 2 grayscale values. The converted digital representation is then compressed and stored. The stored data can be used in facsimile transmission or reprographic image production.

The invention thus provides an improved technique for enabling the efficient compression of the less significant bits in grayscale bitmap applications.

The invention also provides an improved method for compressing successive bit-planes when operating on anti-aliased images, particularly in facsimile and reprographic applications.

The invention also provides a lossless means for storing grayscale bit maps using compression algorithms which are typically used for binary images, such as G3 or G4.

The invention also provides a method for transmitting data or storing data that requires essentially half the transmission time or memory space than prior data storing and transmitting techniques.

The invention is illustrated in the accompanying drawing, in which:

Figure 1 is a diagram of four grayscale values and their binary representations in forming grayscale images thereof.

Figure 2 is an image having the four grayscale values of Figure 1 that is desired to be stored and processed.

Figure 3A is a binary image produced using the least significant bit values of the grayscale values of the image of Figure 2, using prior art techniques.

Figure 3B is a binary image produced using the most significant bit values of the grayscale values of the image of Figure 2, using prior art techniques.

Figure 4A is a grayscale image having a resolution of 400 spi X 2 bits (4 grayscale levels), that is desired to be stored and processed.

Figure 4B is a binary image formed of the image of Figure 4A, having a resolution of 800 spi X 1 bit (2 grayscale levels), produced in accordance with the method of the invention.

And Figure 5 is a block diagram illustrating the steps of processing a grayscale image in accordance with the invention.

As will become apparent, the invention is particularly useful in processing an image that has multiple grayscale values. An arbitrary image having the four grayscale values shown in Figure 1 is depicted in Figure 2. The image of Figure 2 is depicted as it might be processed by a scanner or other device known in the art, and is partitioned into pixels 12, each of which having a particular grayscale value.

The four grayscale values shown in Figure 1 are numbered 0-3, representing increasing levels of black from white. Thus, the first level 0 is white, and, when mapped to a two-bit binary value, has a grayscale val-

of reprographic machines that have different resolution scanning and copy or printing reproduction capabilities. For example, if a particular hard copy device has a scanning and reproduction resolution of 400 X 3, a digital representation of the image can be converted to a higher resolution, for instance of 1200 X 1. If another copier, or printer, has, for instance, a different resolution, such as 600 x 1, then interchange from the lower (400, gray) to higher (600, binary) resolution machine can be made by decompressing the intermediate (1200) very-high-resolution image with every other pixel and every other line used to compose the 600 x 1 image for the higher resolution machine, thereby introducing minimal image distortion.

It will be appreciated that the method of the invention is not limited to reprographic or facsimile systems. It is useful wherever images are intended to be rendered on a grayscale output device, such as a grayscale display of an image-retrieval system, or the like.

It will be also appreciated that the technique of the invention is most efficient for anti-aliased images, that is, images where gray valued pixels are only found in the sweep between black and white. This technique would not be as efficient if the region were, say, uniformly at gray-level 2 (binary "01") out of 4 grayscale levels.

Claims

1. A method for image processing, comprising:
   scanning an image (20) within a first grid of pixels (22);
   determining a grayscale value for each pixel scanned in said first grid of pixels; and
   for each pixel scanned, activating a number of pixels of a second grid of pixels (25) corresponding to the grayscale value determined.

2. The method of claim 1 wherein said first grid of pixels represents an image of first resolution, and said second grid of pixels represents an image of second resolution at least as large as the resolution represented by the first grid of pixels times the base-2 logarithm of the number of grayscale values that can be detected in said first grid.

3. The method of claim 2 wherein the resolution of said first grid of pixels is about 400 spi (16 spots per mm), and the number of grayscale values is 4, and wherein the resolution of said second grid of pixels is about 800 spi (32 spots per mm), and the number of grayscale values is 2.

4. The method of any one of claims 1 to 3 further comprising compressing the second grid of pixels to form a compressed converted binary image representation, and storing the compressed converted binary representation in a memory.

5. A method for image processing, comprising:
   scanning an image to produce a binary representation of said image at a first resolution and with a predetermined number of grayscale values;
   converting the binary representation of said image to a binary representation of an image having an increased resolution at least as great as the first resolution times the base-2 logarithm of the predetermined number of grayscale values, and having only 2 grayscale values;
   compressing the converted binary representation;
   and storing the compressed converted binary representation.

6. The method of claim 5 further comprising transmitting the compressed converted binary representation as a part of a facsimile data transmission.

7. The method of claim 6 further comprising receiving the transmitted compressed converted binary representation, decompressing the received compressed converted binary representation, and reproducing an image from the decompressed binary representation.

8. The method of claim 5 further comprising decompressing the compressed converted binary representation, and reprographically reproducing an image from the decompressed binary representation.

9. The method of claim 8 further comprising performing an inverse half-tone process on the decompressed binary representation.

10. A method for compressing binary image data having a plurality of grayscale values, comprising:
    converting the image data to a binary representation of an image having an increased resolution at least as great as the first resolution times the predetermined number of grayscale values and having only 2 grayscale values;
    and determining the grayscale values of the converted binary representation from the most significant bits of the image data.

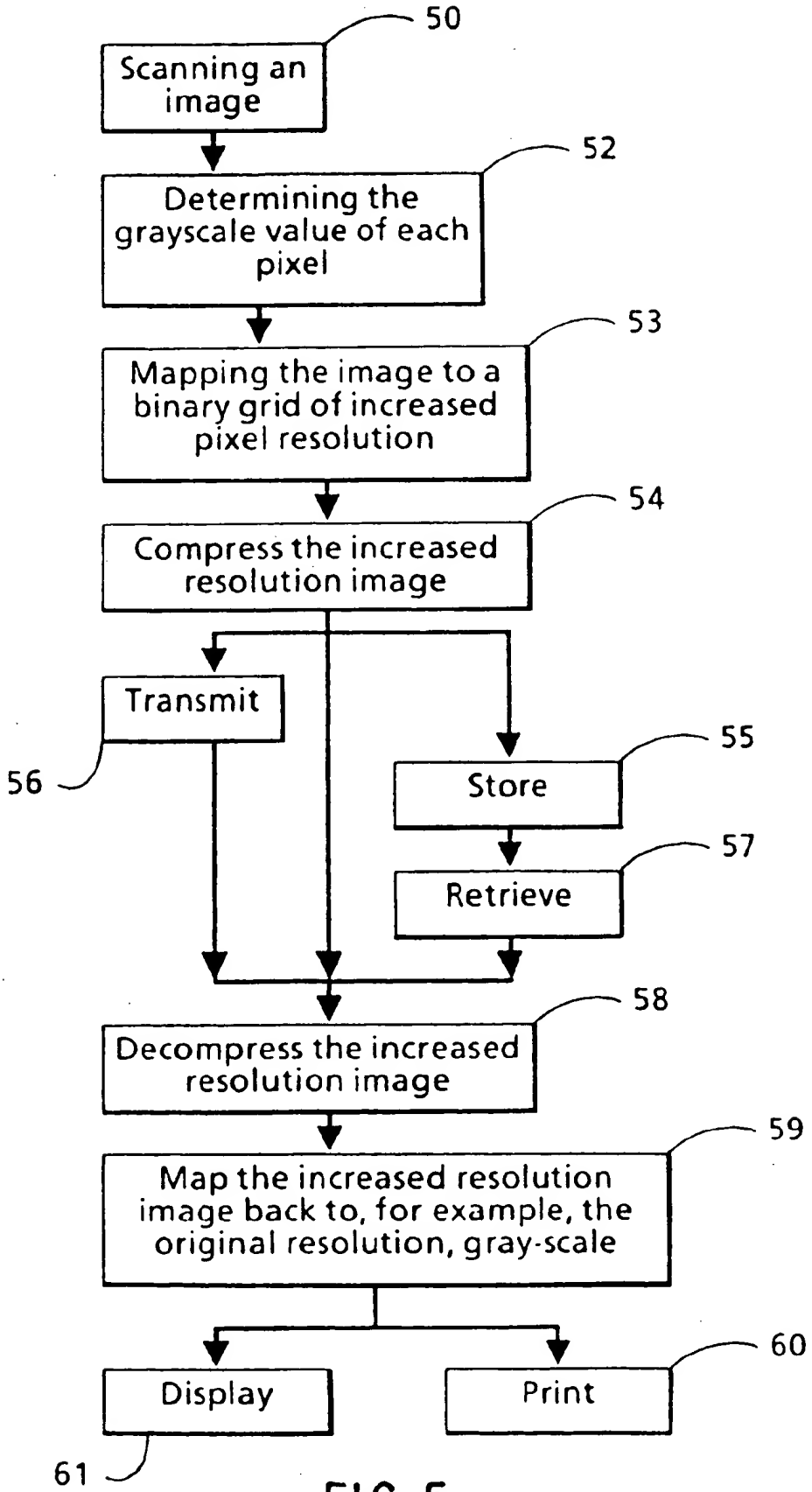
50
Scanning an image
52
Determining the grayscale value of each pixel
53
Mapping the image to a binary grid of increased pixel resolution
54
Compress the increased resolution image
Transmit
56
55
Store
57
Retrieve
58
Decompress the increased resolution image
59
Map the increased resolution image back to, for example, the original resolution, gray-scale
Display
61
Print
60

FIG. 5

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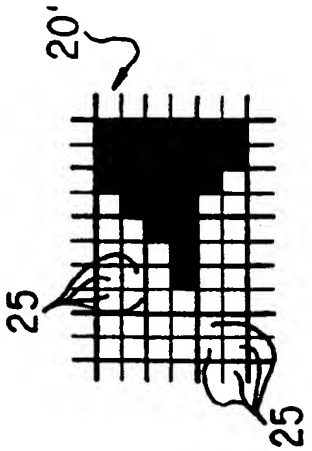

FIG. 4B

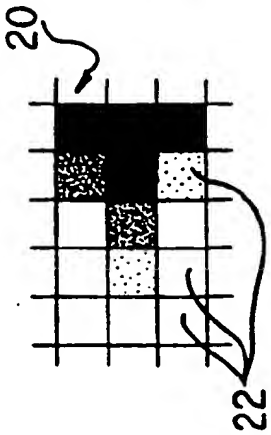

FIG. 4A

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